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CRUNCHING THE NUMBERS ON OUT-OF-FIELD TEACHING

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Crunching the numbers on out-of-field teaching in maths

Out-of-field teaching in mathematics is a deep and difficult problem in Australian secondary schools. It is estimated that between 21 percent and 38 percent of Year 7-10 maths classes are taught by out-of-field teachers, depending on the definition[1]. Combined with the subject's other endemic problems, such as the 20 year decline in the proportion of students taking intermediate and advanced maths at Year 12 and the wholesale retreat from prerequisites by the universities, the future for the mathematics teaching workforce looks grim[23].

The modelling presented here indicates the depth and scale of out-of-field teaching in secondary mathematics. Seen through the lens of remediation, the problem will clearly take at least 10 years to fix even with a united approach from the Commonwealth, the States, the non-government sector and universities. Re-training current out-of-field teachers must be a large part of the solution and new thinking is needed to attract mathematical sciences graduates to teaching. This won't be cheap but the return on investment is priceless, while the consequences of avoidance are dire.

Out-of-field teaching in mathematics not only affects the learning outcomes of students, it limits our schools' ability to mount the intermediate and advanced subjects at Years 10 through 12 which lead to degrees in science, engineering, medicine and so on. It is worst in regional, remote and mid to low SES communities and is therefore an equity issue, not only limiting educational access but driving down adult numeracy. From an economic viewpoint it chokes the supply of mathematically and statistically capable professionals in an era of increasing demand.

Linda Hobbs has recently written of the complexity of the out-of-field problem[4], partly in response to recent comments by the former Minister of Education, Simon Birmingham, urging the universities to graduate more in-field teachers in mathematics and the sciences. Senator Birmingham wanted the problem solved in five to 10 years.

What is missing to date is a quantitative analysis of the issue, answering questions such as:

"What is the likelihood that your child will have at least one, two or three out-of-field teachers between Years 7 to 10?"

"What fraction of Year 7 to 10 students have an in-field maths teacher every year?"

"How long would it take to halve the out-of-field problem if recruitment of freshly trained graduates matched retirement of in-field and out-of-field maths teachers?".

"How many new, in-field teachers would be required to reduce out-of-field teaching to, say, 10 percent in five years? 10 years?"

"Can we solve the out-of-field teaching problem with new graduates alone?"

Our work at AMSI indicates that the supply of new graduates alone cannot solve the out-of-field problem on any acceptable time scale. Retraining of out-of-field teachers must be a major part of any approach. It is possible to estimate the scale of this retraining operation at the same time as we work towards graduating enough new teachers to match retirements.

SOME ASSUMPTIONS

The analysis here is based on some simplifying assumptions. It is intended to establish the scale of the problem and not provide the most definitive predictions.

First of all, we will assume that the retirement rate of out-of-field and in-field maths teachers is the same at approximately five percent[5]. It is, however, known that early career teachers do more out-of-field teaching than their older peers[6].

Secondly, we assume that the out-of-field rate in mathematics is constant across years and all jurisdictions at an indicative 30 percent. This corresponds to a definition of in-field teaching requiring one semester of study in the subject at second year[7]. As an aside, AMSI regards this level of preparation as inadequate, especially for teaching at Year 10 and above. Of course, these assumptions are only valid on limited geographic or socio-economic scales. And it may be that out-of-field teaching is more prevalent in Year 7 than in Year 10; more on this later.

Third, we will assume that maths takes up 18 percent of Year 7 to 12 class hours[8], so that teachers of mathematics, both in and out-of-field, make up 18 percent of the secondary teacher workforce. In 2017 the ABS[9] reported a full-time equivalent workforce of 135,526, meaning that the maths teacher workforce was 29,395 of which 7318 (30%) are out-of-field. We will assume that the total

1 Weldon, Paul R., "Out-of-Field Teaching in Australian Secondary Schools". ACER Policy Insights Issue 6, June 2016.

2 Wienk, M., "Discipline Profile of the Mathematical Sciences". Australian Mathematical Sciences Institute 2017.

3 "Improving Australia's Maths Grades". Australian Mathematical Sciences Institute 2017.

4 Hobbs, Linda, "Universities can help recruit more science and maths teachers, but they can't do it alone". The Conversation, July 20, 2018.

5 Willet, Mike, Segal, Daniel and Walford, Will. "National Teaching Workforce Dataset Data Analysis Report 2014" Commonwealth of Australia 2014.

6 Weldon, op. cit.

7 Weldon, op. cit.

8 Around 20% of class hours in Years 7 to 10 and around 16% in Years 11 & 12. This is less than the 20.9% estimated in the 2014 ACER Report "Staff in Australia's Schools 2013: Main Report of the Survey"

9 Australian Bureau of Statistics 2017 http://www.abs.gov.au/ausstats/abs@.nsf/0/9448F2F814FA0311CA2579C700118E2D?Opendocument

workforce size is constant, at least on the time scales considered here. The assumed 5 percent retirement/attrition rate means 1220 teachers of mathematics leave the system each year.

There are some critical facts that are not known (to us or anyone else, including the Commonwealth): the current national or State graduation rates of in-field mathematics teachers, and the percentage of new graduates who don't reach the classroom.

Finally, our thesis is that we should aim to match new, in-field teacher recruitment with in-field and out-of-field retirement/attrition. This is because our schools are fully staffed. So, if there is an under supply of recruits then out-of-field teaching will increase. Conversely, if there is an oversupply then new graduates and existing teachers will be out of work.

QUESTIONS AND ANSWERS

Let's start off with the questions requiring fewest assumptions:

"What is the likelihood that your child will have at least one, two or three out-of-field teachers between Years 7 to 10?"

"What fraction of Year 7 to 10 students have an in-field maths teacher every year?"

Assuming a conservative, uniform, national out-of-field rate of 30 per cent across Years 7 to 10, this question requires the use of the binomial distribution, well known to Year 12 students, with n=4 (the four 7 to 10 years thought of as trials) and p=0.3 (the probability of having an out-of-field teacher in any one year).

The answers are: there is a 76 per cent chance of at least one out-of-field teacher, 35 per cent for at least two and 8 per cent for at least three years of out-of-field teaching.

Less than one in four Year 7 to 10 students have an in-field maths teacher every year.

This is alarming – on average three quarters of Australian students are taught by an out-of-field maths teacher at least once in these important years and a third of them have at most two years with an in-field teacher. The flip side, that less than one in four students have a qualified maths teacher in each of Years 7 to 10, is a particularly stark reality, especially given the nonuniformity of out of field teaching.

Now, for reasons of pedagogy it may be better to get this out-of-field experience out of the way in Year 7 and 8 rather than in Years 9 and 10. Would this change the likelihood that a student would experience at least two years of out-of-field teaching? This is a harder mathematical problem, but it turns out that having equal likelihood at each year level minimises the overall likelihood of at least two (or three or four) years of out-of-field teaching. So, strategies like localising the out-of-field experience to earlier years will make the overall problem worse.

Now to the other questions. Firstly,

"How long would it take to halve the out-of-field problem if recruitment of freshly trained graduates matched retirement of in-field and out-of-field maths teachers?".

The answer to this is 13.5 years.

This calculation requires some undergraduate maths and we have assumed that out-of-field teaching is at 30 percent and the retirement/attrition rate of all teachers, both in-field and out-of-field, is 5 percent.

The result is also alarming, especially since we are clearly not now recruiting in-field teachers at anywhere near the rate of retirement. It would take 13.5 years of healthy graduations to bring out-of-field teaching to 15 percent, still a far from acceptable rate. And if we aimed to reduce out-of-field teaching to 10 percent it would take 21 years! If the rate is worse than 30% or fewer out-of-field teachers retire, then this half-life blows out even further. Both 13.5 and 21 years are outside the aspirational five to 10 year range!

So, what can we do to deal with the problem in five to 10 years?

"How many new, in-field teachers would be required to reduce out-of-field teaching to 10 percent in five years? 10 years?"

Our analysis shows

Answer 1: in relative terms we would have to recruit these teachers at 160% and 120% of the retirement rate per year respectively.

Answer 2: in absolute terms we need to recruit around 1900 and 1500 in-field teachers per year respectively.

The answer in relative terms is important for planning because it does not require the estimated current numbers of maths teachers in the system.

Given that recruitment of new graduates should match attrition and retirements, the conclusion is clear. We should retrain existing out-of-field teachers to make up the shortfall. This means for every thousand new graduates per annum we need to retrain an additional 600 out-of-field teachers for a five year solution and 200 out-of-field teachers per year for a 10 year solution. Of course, if the new graduate supply doesn't match retirements then we must retrain more out-of-field teachers.

But we really need some hard numbers because our universities and employers need to know the challenge they will face. The figures in Table 1 are based on the assumptions about the workforce size, etcetera, identified above. All estimates are rounded to two significant figures. In our view reduction of the out-of-field rate to 10 percent, even in 10 years, will be challenging.

Target out-of-field rate *(currently 30%)*	**Total recruitments** *required per annum including retrainees*	**New graduates** *required per annum to match retirements*	**Retrained teachers** *required per annum (% of current out-of-field workforce)*	**Total retrainees required over the time period** *(% of current out-of-field workforce)*
15% in 5 years	1700	1200	440 (6.1%)	2200 (30%)
15% in 10 years	1300	1200	90 (1.2%)	900 (12%)
10% in 5 years	1900	1200	710 (9.7%)	3600 (49%)
10% in 10 years	1500	1200	240 (3.3%)	2400 (33%)

The supply of out-of-field teachers wishing to retrain is far more certain than the supply of new graduates needed to match retirements. A more sophisticated and realistic model, easily built once the data is to hand, would begin with the current graduation rate of new in-field teachers and then grow to match retirements on some viable time scale. This model would also, of course, predict the corresponding increased extent of retraining required.

One last question: ***how big is the current pool of students graduating in the mathematical sciences each year?***

AMSI surveys its member university departments each year and our current estimate of the total number of full-time equivalent students in third year mathematics is around 1500[10]. A small proportion of these will undertake teacher training with many more heading into further study or lucrative employment in an economy hungry for data science, optimisation and algorithms. Clearly, our universities must increase undergraduate numbers in mathematics and statistics to restock the teacher workforce. We leave the reader to ponder how this might be done when the social demographic which produces school teachers is so poorly supplied with in-field teachers of mathematics!

Australia is not alone in having a severe out-of-field problem in mathematics. However, the combination of multiple jurisdictions and institutions which train, employ and register teachers has made our problem almost intractable. The time for shouting at the issue has long passed, what we need now is leadership.

10 This does not include all students taking a mathematics specialisation in a Faculty of Education.

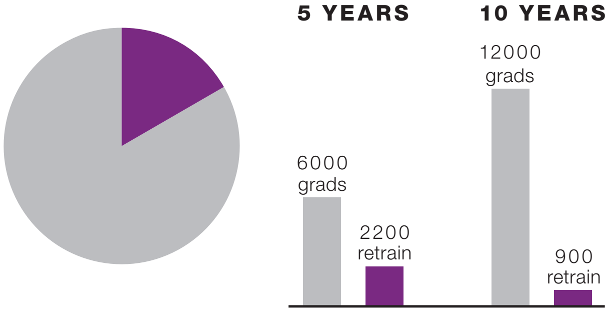
Number crunching our maths teacher shortfall

1 in 3

secondary maths classes are taught by out-of-field teachers

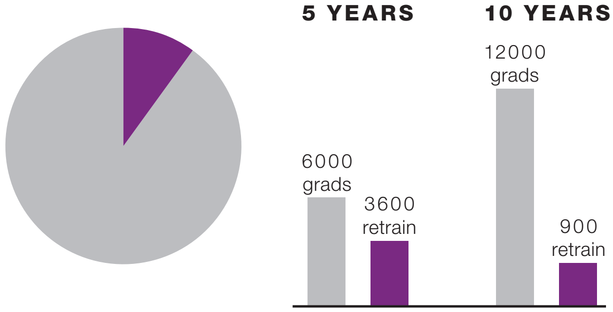
AMSI has crunched the numbers to reverse the out-of-field teacher shortfall in Australian schools

1 in 6 classes

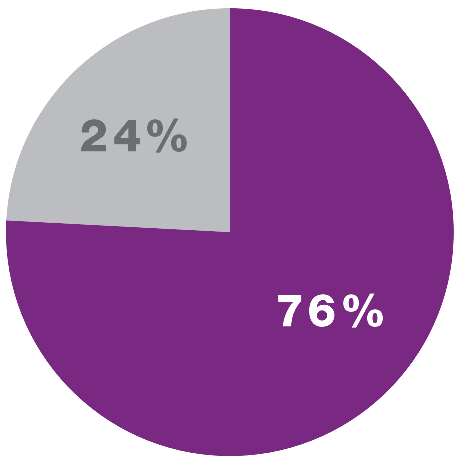


*This **optimistically** assumes that graduate numbers **will** match retirements at 1200 **per annum**

1 in 10 classes



Secondary students taught by an out-of-field teacher from 1–4 years.



76% of secondary students will be taught maths by an out-of-field teacher for 1 or up to all years from Years 7-10

Only 24% are taught by a qualified maths teacher every year